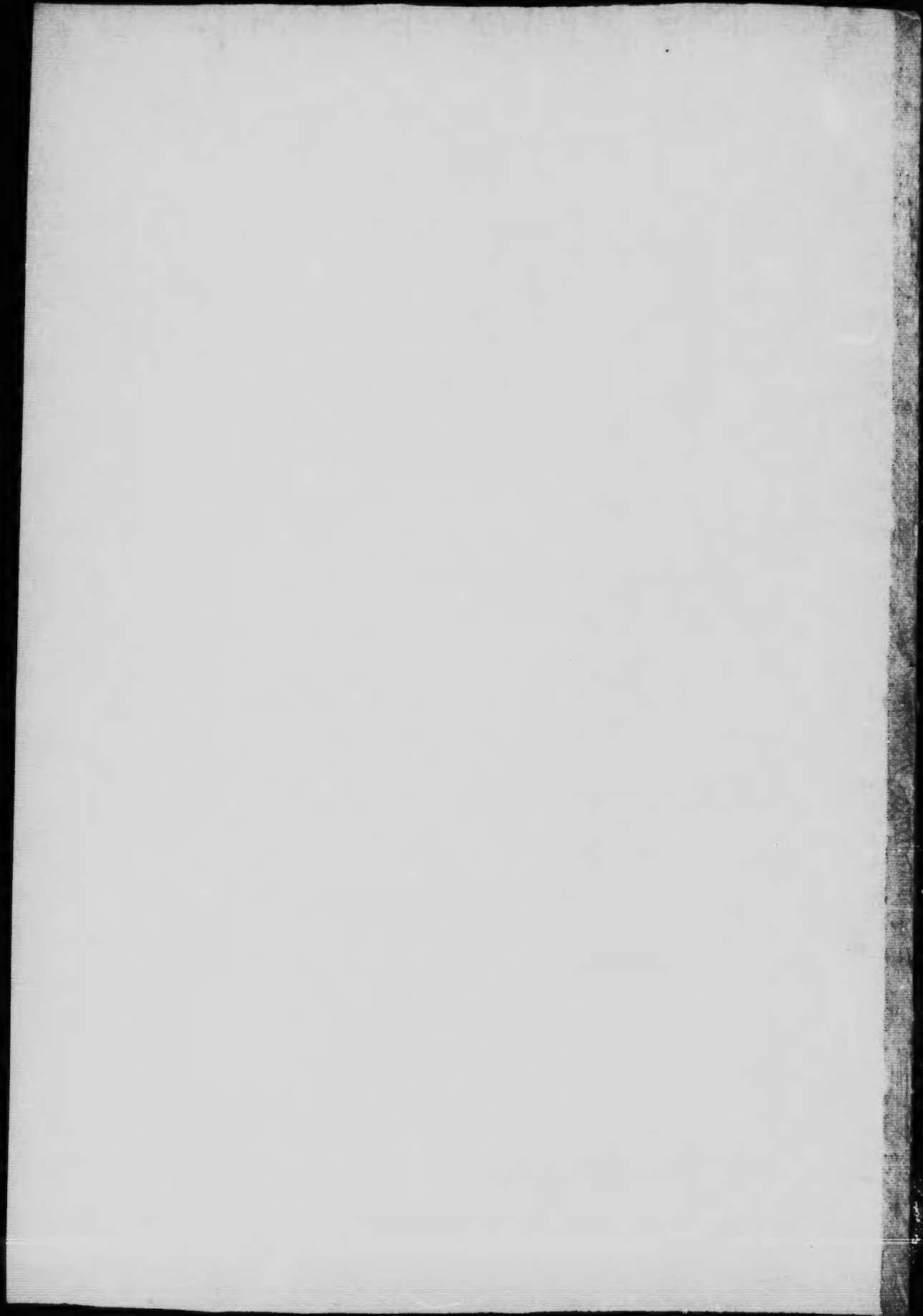
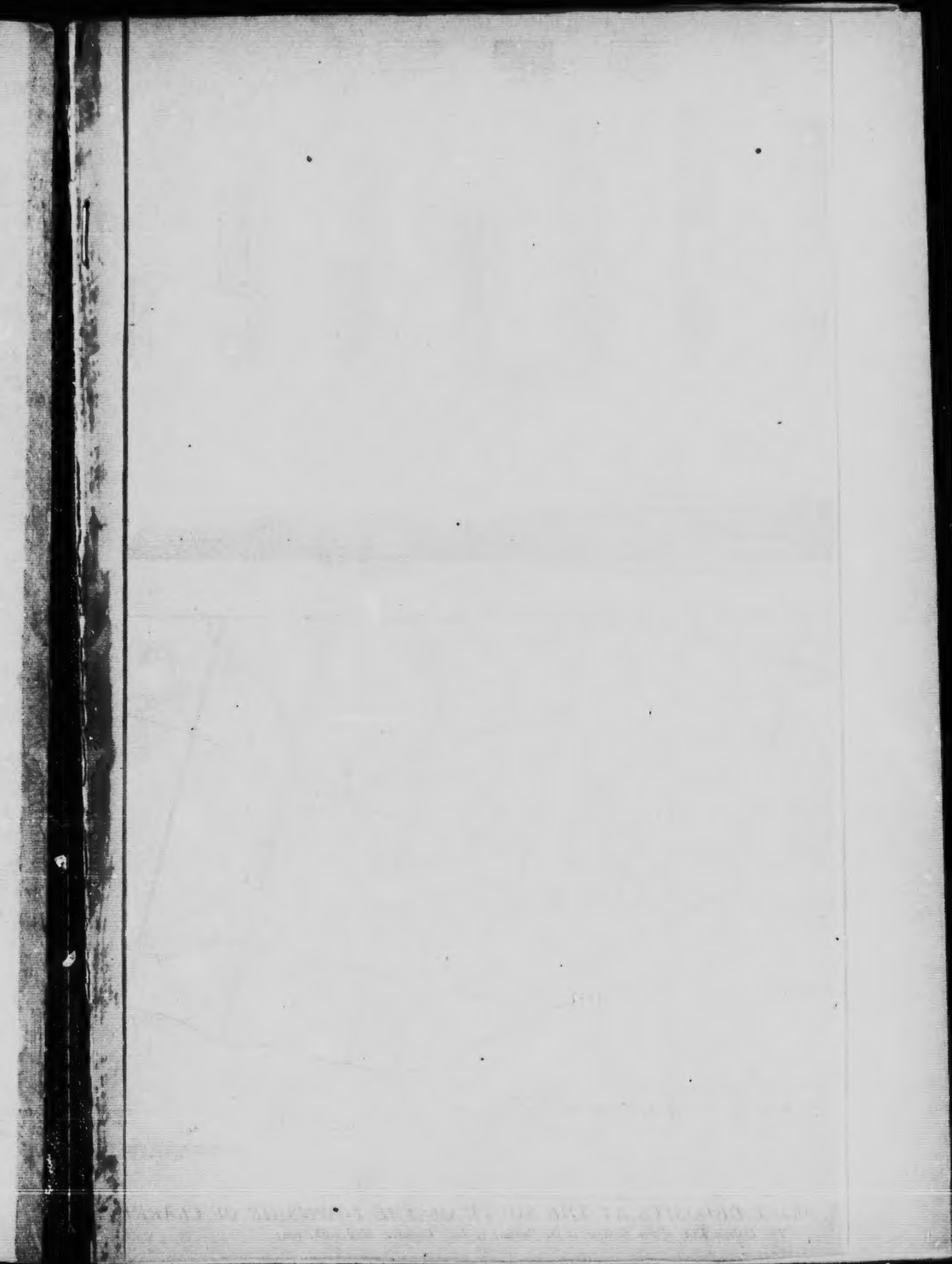






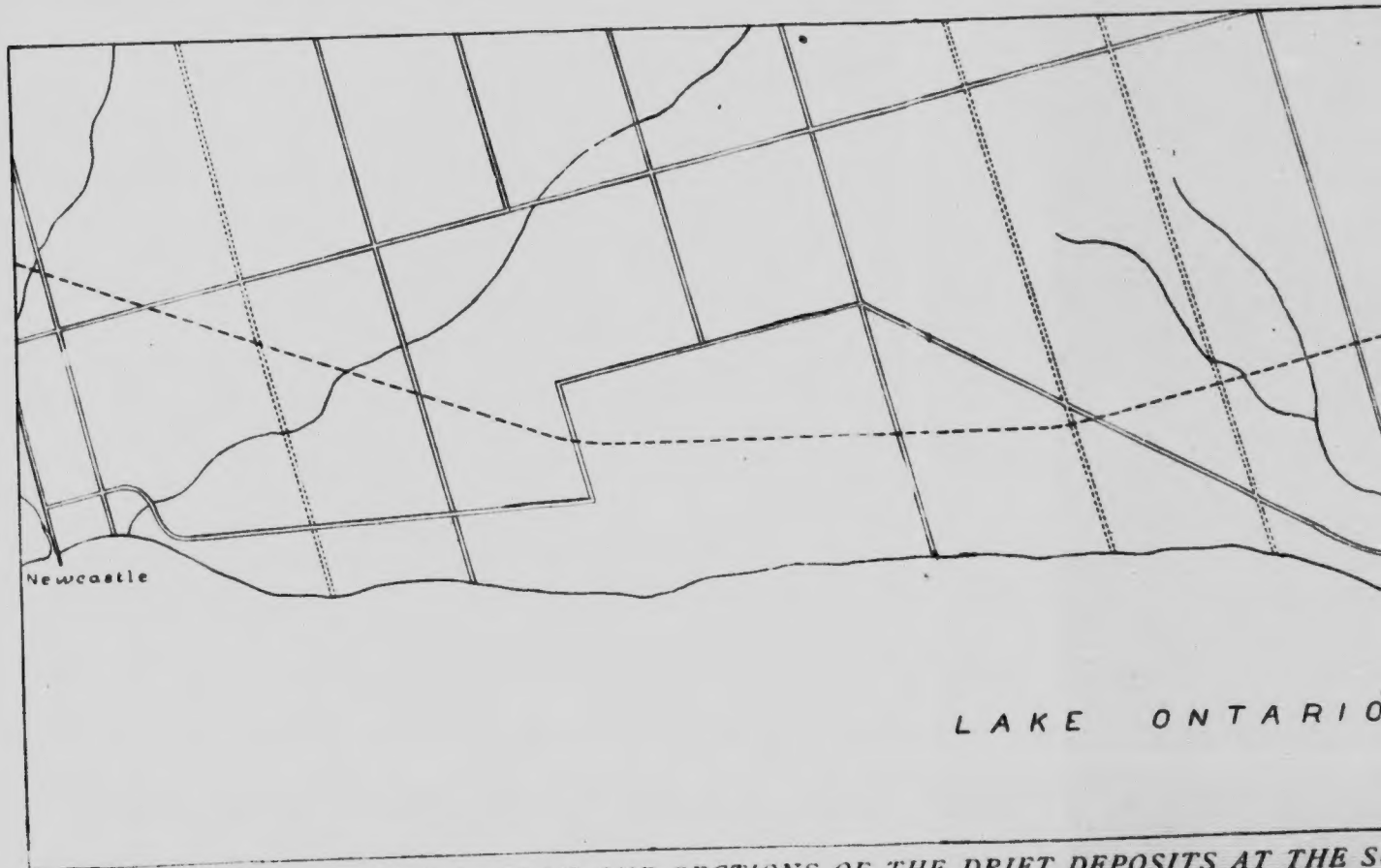
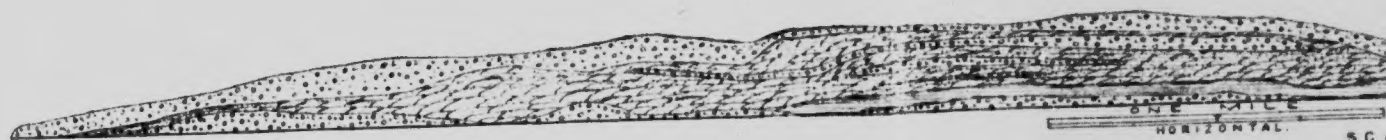
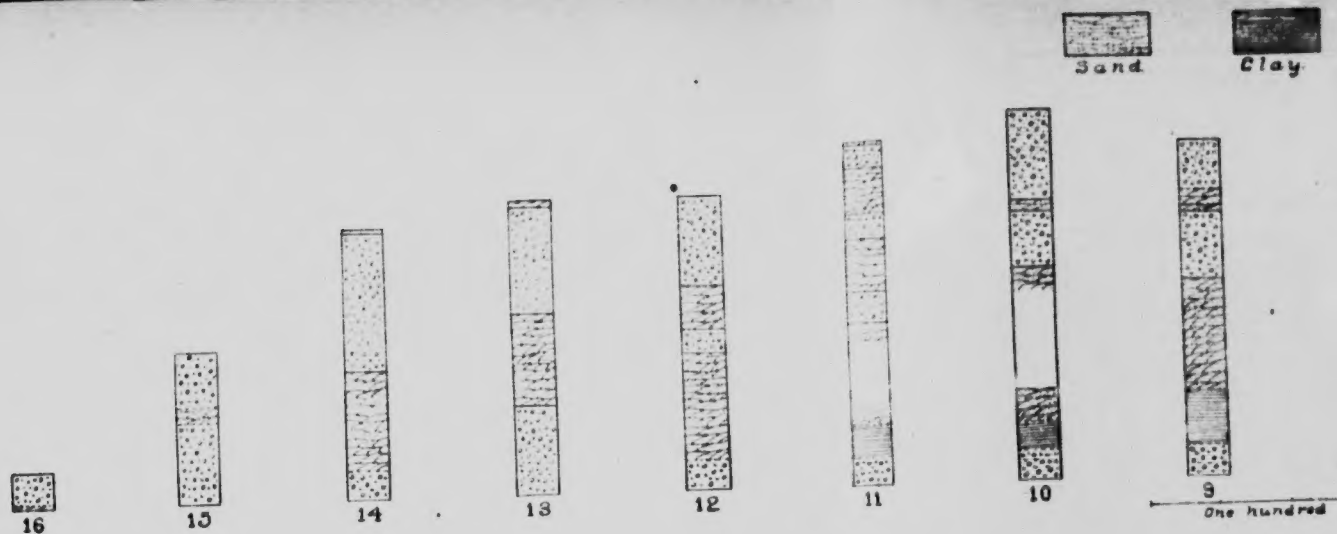


PLATE I.—PLAN AND SECTIONS OF THE DRIFT DEPOSITS AT THE S
The Datum Line of the Sections is the S

Clay

Till

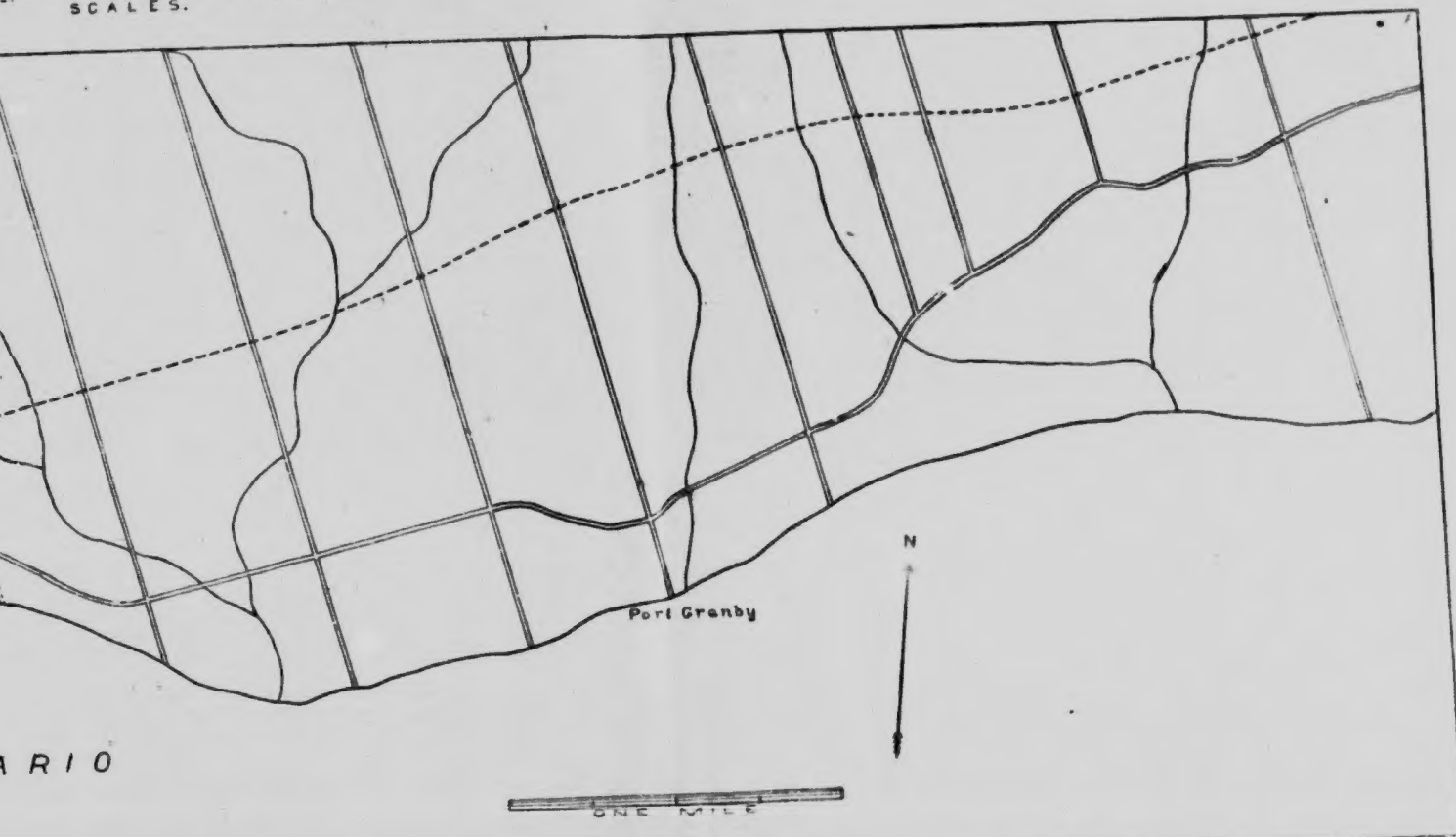


hundred feet.



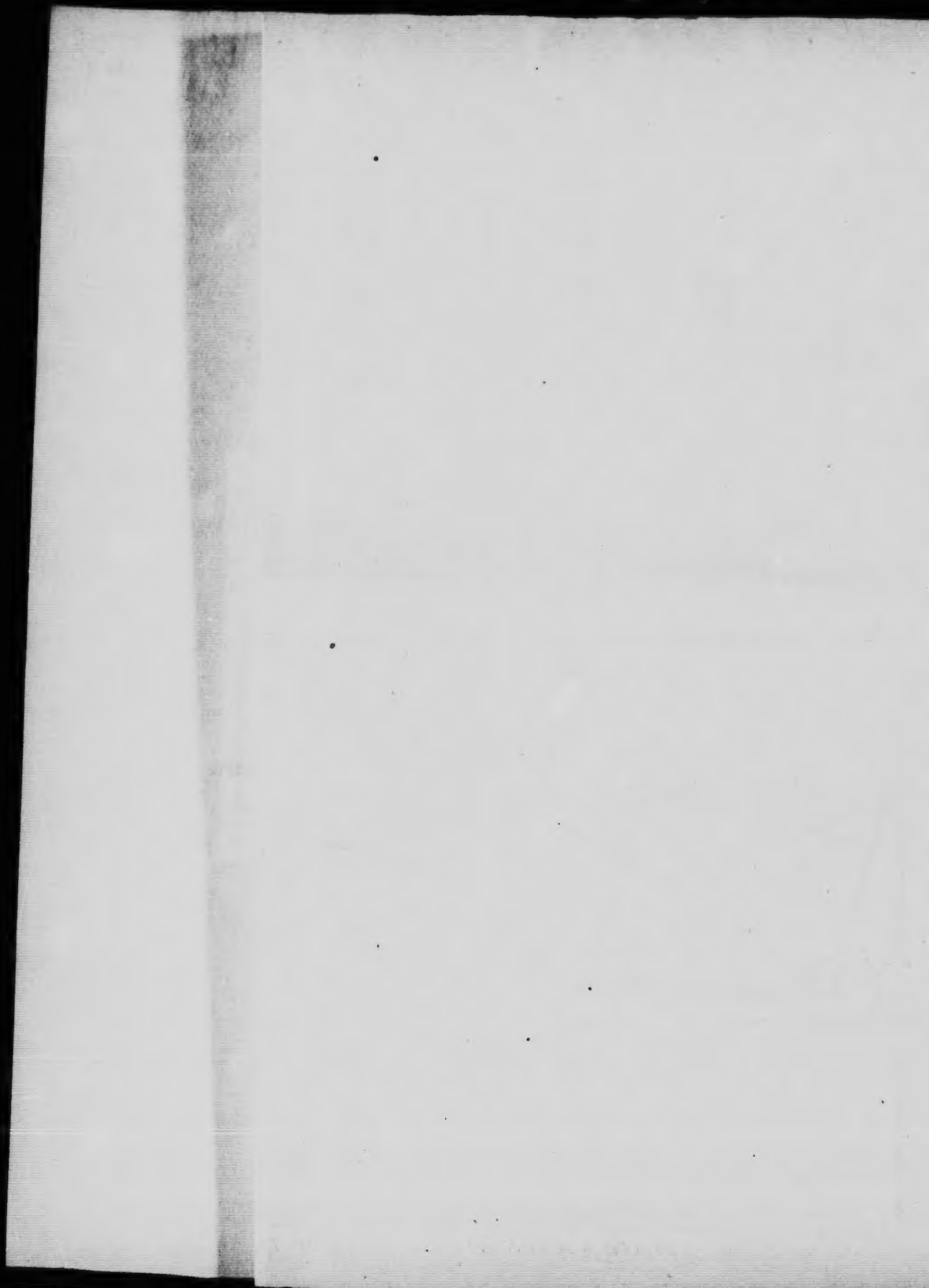
SCALE.

VERTICAL



ARIO

THE SOUTH OF THE TOWNSHIP OF CLARKE, DURHAM COUNTY, ONTARIO.
This is the Surface of Lake Ontario, May 20th, 1903.



A FORTY-MILE SECTION OF PLEISTOCENE
DEPOSITS NORTH OF LAKE ONTARIO.

BY

ALFRED W. G. WILSON
MCGILL UNIVERSITY, MONTREAL

(Read before the Canadian Institute, Toronto, March 7th, 1904)

TORONTO:
MURRAY PRINTING COMPANY, GLOBE BUILDING.
1905.



are a number of places where the shore is formed by a barrier beach built by the waves, and the pleistocene deposits pass under the beach, no exposures being visible. Between these barrier beaches there are several places in which we find low cliffs, varying in height to a maximum of about twenty-five feet. The deposits in which the cliffs are cut consist chiefly of a compact and, in places, arenaceous till carrying numerous pebbles, cobbles, and some boulders. Overlying the till sheet, which is of irregular thickness, is a deposit of fine textured stratified sands. In places the low cliff is cut wholly in the sands, the till presumably being below water-level. In one locality the waves are now cutting into an old sand dune which must be of comparatively recent origin. About a mile and a-half west of Lakeport, at Ogden's Point, bed rock is not exposed on the shore, but it can be seen off shore beneath about six feet of water. The next exposure of rock occurs at Grafton point, about five miles west of Lakeport. At the point and for a short distance west of it the rock seems to be overlain by a deposit of stratified sand, though it is probable that there is a thin drift cover beneath. Immediately to the east of Grafton pier there is a small exposure of white clay till, apparently the remnant of a drumlin, now almost completely washed away by the waves. Commencing about a quarter of a mile east of the pier and extending for one and a-half miles is a cliff about thirty feet in height at its maximum, the upper part of which is formed by stratified sands. If the till occurs above lake level and beneath these sands it is obscured by the talus from the cliff. Beyond this cliff, eastward, the shore is bordered by a barrier beach the gravel of which is probably derived from a till deposit underlying the sands of this cliff. Still further east similar sands again form a low cliff, giving place, near Ogden's Point, to an arenaceous clay till, carrying numerous pebbles, cobbles, and some very large boulders and blocks. In places the till is overlain by thin deposits of sand. Just east of the point, and extending to Lakeport, the till forms a cliff about twenty feet in height. The surface rises rapidly inland to an elevation of about forty feet. Allowing for that which lies below water-level the total thickness must be about forty-five feet.

West from Grafton Point the upper surface of the sands which form the low cliff at the point, gradually becomes lower so that the land slopes gently down to lake-level. About three miles west of the point deposits of a compact argillaceous till again form a steep cliff with a maximum height of thirty feet, but gradually lowering both east and west. This till passes beneath the sands on either side of it. Continuing west along the shore the till gives place to sands. About three miles

and a-half east of Cobourg pier, immediately beneath these sands and overlying a deposit of boulder till, are found about eight feet of a distinctly stratified clay which presents a peculiar banding. The section is about one quarter of a mile in length. The banded appearance of the clay is due to the alternate deposition of fine and slightly coarser materials in beds varying from one-half to one inch in thickness. In this bedded clay are found numerous pebbles and small cobbles, some of the latter being distinctly striated. The most striking feature of the banding is that in places it is very much twisted and contorted, so much so that the contortions can be best likened to those found in contorted gneiss.

For the next five miles, to a little beyond the western boundary of the town of Cobourg, clay till occurs with bed rock outcropping from beneath it at frequent intervals. This till reaches its maximum thickness, about forty-five feet, a mile and a-half east of Cobourg pier. In the western part of the town the upper surface of the till near the lake is below water-level and is overlain by sand deposits. It again appears in a dome-shaped hill at Weller's Point a little further west. For the next mile, west from Weller's Point, the till is again overlaid by sands. The upper surface of these sands gradually descends to lake level, and from Green Point to within a mile of Port Hope the shore is formed by a barrier beach.

A mile off shore opposite Green Point lies Gull island, the most westerly exposure of Trenton limestone found along the shore of Lake Ontario.* Under the water there are numerous cobbles and a few boulders still lying on the bed rock. It is not improbable that at one time the island was formed by a drumlin, now long since removed by the waves.

The till sheet which forms the cliff east of Port Hope harbour extends along the shore for about a mile until it is interrupted by Smith's creek, which enters the lake at this place. A third of a mile west of the pier the shore section shows that it is overlaid by stratified sands. Half a mile further west these sands in turn are found to be capped by a second boulder till. A section at this place shows above lake level five feet of the lower till, ten feet of stratified sand, and six feet of the upper till. The thickness of the sands between the till sheets diminishes towards the west and at a mile and a-half west of the town the upper till rests upon the lower. A little over two miles west of Port Hope the

* Limestone is exposed in the bed of Smith's creek at Port Hope, a few chains north of the harbour.

sands again appear between the two sheets and the cliff section is about fifty feet in height. At three miles the upper till overlies the sands and the lower till lies below lake level. From this point for the next two miles the shore-line is marked by a barrier beach, the land behind is low and marshy. Then two low domes of the lower till form a low cliff for about one-quarter of a mile. A second barrier beach more than a mile in length intervenes between these low cliffs and the next series of deposits into which the waves have cut. From this place, about two and one-half miles west of Port Granby, to Newcastle pier there is a continuous section over eight miles in length, except for slight interruptions where two small creeks enter the lake. This section may be termed the Clarke section, because the greater part of it lies within the township of Clarke.

The structure of this section is much more complex than that of any of the preceeding sections and it has accordingly been studied in more detail. The shore line of Lake Ontario, represented on the accompanying map, was surveyed by means of a Rochon micrometer and a surveyor's compass, the relative positions of the various sections being determined at the same time. The writer is much indebted to the Rev. E. M. Burwash, of Toronto, for assistance in the prosecution of the survey. The topography north of the shore line is taken from a county map, and although it is not as accurate as could be desired, it will serve to show the relative positions of the various sections. In studying these deposits about thirty-five vertical sections were measured, generally by means of a hand level and jacob's staff, and of these, sixteen, at intervals of half a mile, are represented in the upper part of the accompanying plate. The cross section shown in the middle of the plate represents a continuous cross section of the deposits with a vertical exaggeration of ten.

Proceeding from east to west, at two miles east of Port Granby, a lower till is exposed in a low cliff. As we go west the cliff gradually increases in height. At the end of the first half mile this lowest till sheet is found to be overlaid by another sheet of an arenaceous till, which will be termed the third till sheet.* The eastern edge of this till sheet is well marked by a sudden increase in the height of the cliff; it continues inland as a low terrace. Half a mile further west these two till sheets are separated by about thirty-two feet of cross bedded stratified sands (Section 2). A short distance west of this section the sand beds immediately beneath the arenaceous till overlie a series of fine

*The characteristics of the different sheets of till will be described below.

textured stratified clays. These clays rest upon a narrow band of boulder till. Beneath this till sheet, which will be termed the second till sheet, is a second belt of stratified cross-bedded sands. Judging from the topographic expression of the cliff front, the till of the first or lowest sheet probably also occurs here above lake level. The second or middle till sheet extends along the shore for a little over a mile, and appears in Sections 3 and 4. At Section 5 it has disappeared; apparently both it and the underlying sand deposits were eroded before the arenaceous till of the third sheet was deposited, because the third sheet rests unconformably upon them.

What is regarded as the continuation of this second till sheet is again found about a quarter of a mile west of Section 8, there being an interval of a little over two miles between the exposures. The sheet with the stratified sands exposed both above and below it, may be traced westward for two miles, or to within a little less than two miles of Newcastle. The eastern part of this second sheet has a maximum thickness of twelve feet, as shown in Sections 3 and 4. The sheet reaches its maximum thickness of twenty-five feet a little to the east of Section 9. West of Section 9 the thickness gradually diminishes to about eight feet at Section 12. A little to the west of this the sheet apparently ends and the arenaceous till is found to rest upon cross-bedded sands (with thin beds of gravel), which are continuous with those beneath the second till sheet further east.

Half a mile east of Newcastle, midway between Sections 15 and 16 the cliff presents the following section in ascending order from present lake level :—

Upper till.....	Upper part substratified	5' 9"	} 32' 5"
	Lower part massive.....	26' 8"	
Stratified Sands {	Laminated argillaceous sands.....	6"	} 14' 4"
	Sand free from clay.	1' 2"	
	Laminated argillaceous sands	2' 8"	
Lowest till (top of sheet).....		1' 0"	} 2' 0"
Modern beach		2' 0"	
			39' 9"

The surface of the lowest till sheet which here shows above the lake level is gently undulating, and a few yards west of where the above section was taken it rises to six feet above lake level, while the thickness of the upper sheet has diminished.

The lowest till sheet lies below water level at Section 4 and at Section 7. At Sections 5 and 6 there is reason to believe that it is present

above lake level; but the base of the cliff is so obscured that this could not be proven. It reappears along the shore in several places west of Section 8, but as a rule the exact height of the upper surface above lake level could not be ascertained until within a quarter of a mile east of Section 13, where it is five feet. The height increases rapidly to thirty-two feet above lake level at Section 13. From here it gradually descends towards the west, passing below lake level west of Section 15.

Midway between Sections 10 and 11, three miles east of Newcastle, the following section was obtained:—

Upper till, arenaceous and substratified (third sheet).....	8'
Sands, cross bedded.....	8'
Till, massive (second sheet).....	12'
Sands and some gravel.....	16'
Till (intermediate sheet B).....	11'
Stratified sands { Sand, moderately coarse..... 2' }.....	13'
{ Clays with sandy beds..... 9' }.....	
{ Sand, evenly bedded, coarse.. 1' }.....	
Till (intermediate sheet A).....	5'
Sands, cross bedded.....	11'
Laminated clays.....	19'
Measures partly concealed (probably first till sheet).....	15'
	117'

In this section it will be noted that there are four beds of till exposed above the laminated clays which in several sections along the shore are found to overlie the lowest till sheet. The two intermediate sheets (A and B above) appear here between what have been termed the first and second sheets. The lowest of these sheets, A, has a thickness of five feet. It was not found in other sections on either side, and it is quite certain that its length in the cross section exposed along the lake shore is only a little over half a mile. It is probable that it reaches as far west as Section 11, but it could not be located on account of the talus cover. The next till sheet above this, B of the section, has a thickness of eleven feet. It also occurs in Section 11 with the same thickness. It is uncertain whether it is present in Section 10 or not. If so it does not extend much to the east of that section, and its total length in cross section is a little over one mile.

The uppermost or third till sheet is exposed continuously along the whole length of the Clarke section.

THE TILL SHEETS.

The first or lowest till sheet consists of a fine textured and very compact clay in which there is a small amount of sand, numerous pebbles and small cobbles, derived chiefly from the underlying limestone, with a very much smaller number derived from the archæan rocks. Scattered through the till there are frequently found larger boulders and blocks, usually of gneiss, granite, or some of the associated rocks; occasionally large boulders of the Trenton limestone occur. The boulders appear to be segregated in different parts of the till, there being long stretches nearly free from them between the localities where they are particularly abundant. The sheet has nowhere been found to present the slightest trace of stratification, even in the thickest sections. Wherever the bed rock is exposed this sheet is found to rest directly upon it. Its upper surface is undulating, so that at times it rises in dome-shaped hills above the surface of the lake, at times it lies below present water level. The maximum thickness observed in the lake-shore sections here described is about fifty feet.

The till of the second sheet, and of the two smaller sheets lying beneath it (designated A and B in the section given above), is almost identical with that of the lowest sheet, except that it seems to be slightly more arenaceous, the pebbles are smaller and less numerous, and boulders are almost wanting. The sheets preserve a very uniform thickness throughout their extent, being thus in very marked contrast to the lowest sheet, whose upper and lower surfaces are both irregular. The writer is inclined to regard the two small intermediate sheets of till as marking temporary and local advances and retreats of the ice sheet by which the till of the second sheet was laid down. In the field the actual ends (in the lake-shore section) of neither of these sheets could be located, although it is possible to assign a maximum length. The evidence available does not warrant the conclusion that they were of much greater extent and were eroded before the deposition of the second till sheet or of the sands immediately beneath it.

The uppermost, or third till sheet, differs much from any of the preceding. In many places it consists of two distinct portions, a lower part closely resembling the till of the lower sheet, and an upper part with a well-developed bedded character, and composed of a loose, sandy till in which there is but a small amount of clay. In the field it was not found possible to map the two portions separately. In places the two are very intimately associated. The clay portion will occur in

bands, varying in thickness from a few inches up to about two feet, with beds of the sandy till, often showing traces of stratification, both above and below it. At the point just west of Section 15 the sand and gravel lenses in the upper till sheet are separated by masses of clay from two to four feet thick. These sand and gravel beds are from one-half to two feet in thickness and about fifty feet or less in length. They are looped downward in the middle so that they appear in the cliff-face as if hung in great festoons. At times the stratification planes are found even in the clay portions of the deposit. Where the bedded structure is well developed it is often found to be remarkably contorted and twisted. Masses of the hard clay portions are occasionally found whose greatest dimensions, as shown in cross section in the cliff face, are vertical, and between them there will be found patches of cross-bedded sands. In the sandy portions of this till sheet there are often found large lenses of coarse gravel. One of these, four feet in thickness and several yards in length, appears to divide the upper till into two parts in the vicinity of Section 6, just west of Port Granby. About three quarters of a mile west of Port Granby, at Section 7, the upper till reaches the greatest thickness. Here gravel lenses, intimately associated with masses of unstratified clays, are particularly well shown, although the stratification, so evident in other parts of the section, is not so prominent a feature at this section. The sheet carries numerous pebbles and many boulders, chiefly of archæan rocks. Striated pebbles occur both in the bedded and in the massive parts of the till. There is a short section of the same sheet shown in the upper part of the cliff west of Port Hope. It seems not improbable that the bedded clays which occur three miles east of Cobourg and were described above may be contemporaneous with this till sheet.

STRATIFIED DEPOSITS.

At the base of many of the sections between Newcastle and Port Granby is found a series of fine unctuous, stratified clays, generally resting directly upon the first sheet of till. The thickness of these clays varies considerably, the maximum being about fifteen feet.

Conformably overlying these clays is a series of fine sands in beds varying from a few inches to several feet in thickness, and usually cross bedded (Plate II., Fig. 1). The maximum thickness of the beds of this first interglacial epoch, including the laminated clays above referred to, is about sixty feet. It varies locally, however.

PLATE II.

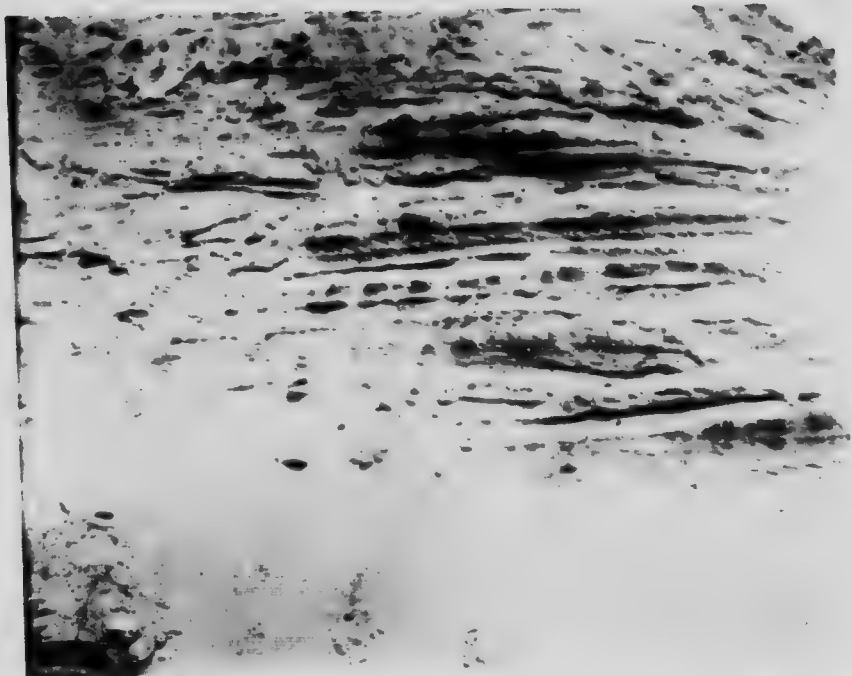


FIG. 1.—Cross-bedded sands of the first interglacial epoch of the locality. The small square micrometer target in the upper right of the picture measures one foot to a side.



FIG. 2.—The complex contact between the till of the third sheet of the locality and the underlying interglacial bed, from near Section 2.

The sands which occur between the two local till sheets (A and B above) are usually coarser than those of the first interglacial epoch, and they contain a few gravel beds. The series of cross-bedded sands of the second interglacial epoch, those overlying the second till sheet, are quite similar to those of the first epoch. The maximum thickness was found east of Port Granby to be fifty-six feet. This includes a few feet of stratified arenaceous clays found at the base of the section.

In none of the stratified deposits could any fossils be found.

In a few places, above the last till sheet, are a few feet of modern deposits—sand blown from the face of the cliff and lodged just behind the edge by the eddying current which exists there when the wind blows towards the cliff front. In one locality these sands have a thickness of five feet. They do not extend more than one hundred and fifty yards back from the front of the cliff.

Inland, north of the shore, there are stratified sands and gravels overlying the last till sheet, but none of them happens to be exposed in the lake-shore sections.

East of Port Hope, wherever stratified sands and gravels occur, they almost always are found to occupy the hollows between adjacent domes composed of the first till. Whether they belong to the first or second interglacial time interval it is impossible to say. As they are found, inland, to give place to till which presumably overlies them, and which probably represents the second till sheet, the inference is that they are contemporaneous with the sands of the first interglacial interval. West of Port Hope the sands are much thicker than elsewhere, and their position intermediate between the two till sheets is easily ascertained.

After the deposition of the sands of the second interglacial epoch there seems to have been an interval of considerable duration in which erosive processes cut broad valleys in the earlier deposits. In the vicinity of Port Granby one of these valleys reached a width of over two miles. A second, whose approximate width has not been determined, occurs in the vicinity of Newcastle.

The till of the last sheet follows the contour of the underlying deposits upon which it was laid down after their partial erosion. At the eastern end of the Clarke section it is found to rest directly upon the till of the first epoch. Elsewhere it usually rests upon the stratified sands of the second interglacial epoch. The relation of this till to the underlying sand deposits is in places very intricate (Plate II., Fig. 2). Sometimes

it appears as if large masses of the clay portion of the till had been forced down into the sands. In others the till has been laid upon the sands with very little disturbance. An uncomformable contact between the massive portion of this till sheet and the little disturbed underlying sands is particularly well shown near Section 4, half a mile east of Port Granby.

CORRELATION WITH THE SCARBORO SECTION.

Until the intervening section, forty miles in length, between that described here and the Scarboro section, has been studied in detail, an adequate correlation of the deposits in the two different localities is impossible. The lowest till sheet in the section here described, which has been shown to be persistent along the shore, with very slight interruptions for the forty miles, is probably the equivalent of one of the sheets in the Scarboro section. The absence of fossils in the interglacial deposits of the Clarke section makes it at present impossible to correlate these deposits with the interglacial deposits at Scarboro. Dr. A. P. Coleman regards it as quite probable that the lowest till sheet in the Scarboro section has no equivalent representative east of that section. The lowest till sheet of the Clarke section and eastward, he considers as the probable equivalent of the second till sheet at Scarboro, and the stratified non-fossiliferous beds immediately above this sheet would then be the equivalents of some of the upper series in the Scarboro section.

In the study of the Scarboro section it was also found that an erosion interval of considerable duration preceded the deposition of the second till sheet. In the section here studied in detail it is found that a prolonged erosion interval followed the deposition of the second interglacial deposits of the locality. It is quite possible that the sheet of till designated the second till sheet in this paper, may not be contemporaneous with any of the till sheets of the Scarboro section, but may merely mark an episode in the general retreat of the ice sheet previous to the deposition of the interglacial beds here regarded as of the second interglacial epoch. It would then be similar to the two intermediate till sheets designated A and B above, and would mark a somewhat larger transgression of the ice sheet. The evidence at present in hand is not sufficient to warrant a correlation of the deposits in the two localities on the assumption that these erosion intervals are contemporaneous and not successive; but, on the other hand, it may be noted that the occurrence of what may be three local sheets of till, separated by stratified

sands, will mark the position of the ice front at a time when interglacial beds of the equivalent time-interval were being deposited west of this at Scarboro and elsewhere.

The arenaceous substratified portions of the uppermost sheet of till differ greatly from the till of the second glacial epoch at Scarboro, but are similar to portions of the highest till sheets of that locality. In the more hurried examination of the entire one hundred miles of sections, made by the writer three years ago, these two till sheets were regarded as probably contemporaneous. The subsequent more detailed study has cast some doubt on this provisional classification. It seems advisable, however, to postpone further discussion until the study of the intervening section, now under way, has been completed.

